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In the underground workings of Wisconsin Steel Coal Mines at Benham, Kentucky, the coal is recovered by drilling eight 7-ft. holes into a working face, loading each hole with 1¼ by 8-in. cartridges of Red H* F permissible powder, and priming each charge with an electric detonator. The holes are fired singly. Results from the blasts approximate 6.1 tons of coal per pound of explosives.

A summary of the mining operations is presented in an article by R. L. Talbert, beginning on page 7.

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With a record of having worked 596,879 man-hours without a lost-time injury in 1949, the employes of Pickands Mather & Company's Embarrass mine at Biwabik, Minnesota, were the winners in the open-pit mines group, in the National Safety Competition. The Sentinels of Safety trophy and flag were awarded to the winning miners at ceremonies held at the mine August 15, 1950, with approximately 300 company officials, employes, and guests participating.

A review of the proceedings begins on page 10.

**

In Part II of a series of three articles entitled "Blasting Vibrations' Effects," Dr. L. Don Leet says that "experience has shown that the applications of Short-Period Delay Electric Blasting Caps improve fragmentation, reduce backbreak and endbreak, and spectacularly reduce vibration in the vicinity of blasting operations. Vibrations are waste by-products of blasting energy. When small, they indicate efficient use of the explosive force doing its main job—breaking rock."

Further details and factual data about this important subject may be found on page 12.

EDITORIAL STAFF: Joseph I. Hoffy, *Managing Editor*; Elizabeth M. Joyce, *Assistant Editor*; Gertrude A. Donnelly, *Assistant Editor*; Edward L. Grant, *Art Editor*; Frank J. Canova, *Production Manager*; Charles E. Rabenold, *Advertising Manager*; Theodore Marvin, *Director*; Montgomery R. Budd, *Associate Director*.

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Views and opinions expressed by the authors of articles in this publication are their own, and they do not necessarily represent those of the publisher.

During the past five years, Cabot Construction Company and the Rock Construction Corporation, Kingston, New York, have concentrated their efforts in subcontracting the drilling and blasting of rock formations on heavy-construction projects in eastern states. Much of their success is attributed to the employment of Short-Period Delay Electric Blasting Caps in the control of rock breakage and in minimizing backbreak and high-bottom rock between blasts.

Please turn to page 17.

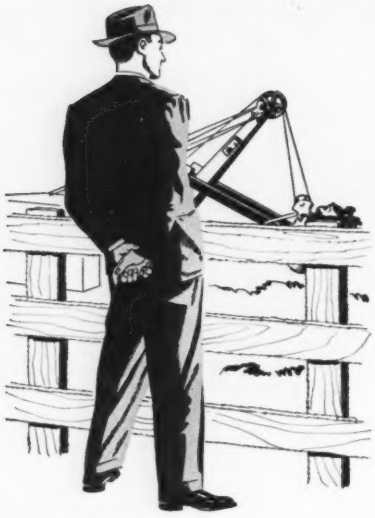
**

In Part III of a series of articles entitled "Tales of a Gold Miner in Nicaragua," C. Carleton Semple relates some of the difficulties he experienced in procuring equipment and in finding suitable workmen to maintain his mining and milling operations. "We had to be satisfied with what we could get and do," he reports.

Part III in the series begins on page 20.

**

For the second consecutive year, Reliance No. 7 mine of The Union Pacific Coal Company was awarded the Sentinels of Safety trophy and flag for the best safety record among 159 bituminous-coal mines enrolled in the 1949 National Safety Competition. To honor the two-time winners, company officials were hosts to approximately 575 employes, their wives, and friends at a dinner-ceremony in Rock Springs, Wyoming, September 22, 1950. A summary of the proceedings is presented on page 24.



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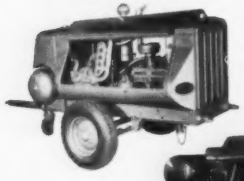

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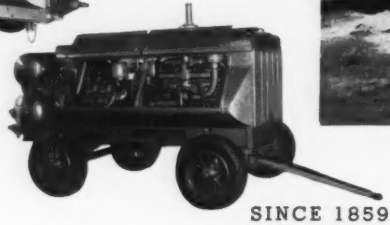

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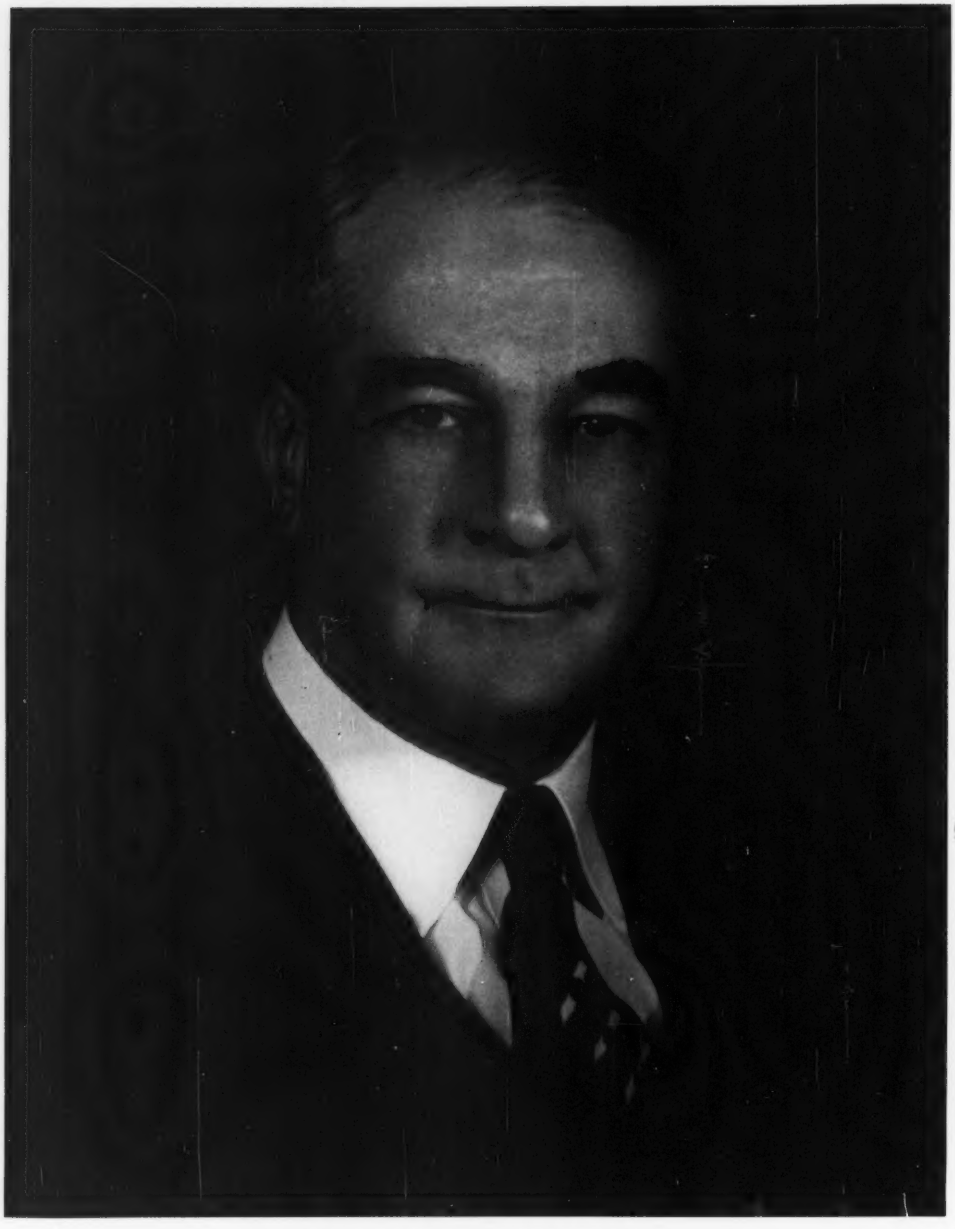


WILLIAM HAROLD HOOVER

William Harold Hoover

PRESIDENT, ANACONDA COPPER MINING COMPANY

A Biography

After William Harold Hoover was graduated from Harvard Law School in 1913, with an LL.B. degree, he returned to Great Falls, Montana, his adopted home town, passed the bar examinations, and became a member of the local law firm of Cooper, Stephenson and Hoover. The firm was counsel for Anaconda Copper Mining Company, and Mr. Hoover was given the responsibility of looking after the mining company's legal business. He did such a good job that Anaconda brought him into its organization at Butte, to be the company's Western general counsel. Later, he was moved to Anaconda's headquarters in New York City, to be its general counsel. In 1943, he was made a vice president of the company; in 1947, a director; and in 1949, its president.

Harold, as he is known to his friends, was born in Lodi, Medina County, Ohio, April 20, 1889, the son of Benjamin F. and Claudia I. (Crawford) Hoover. His father, of Pennsylvania Dutch (Lancaster County) ancestry, was a superintendent of schools and the publisher of a newspaper, *The Enterprise*, in Livingston, Montana. He died when Harold was six years old. Mrs. Hoover, endowed with the courage of her Scotch-Irish ancestry, raised her family of three small children, two boys and a girl, from income received as a schoolteacher.

While on an uncle's farm in Ohio, Harold attended a country school through the eighth grade, walking six miles each day to and from the schoolhouse. Later, he completed the high-school course in Great Falls, Montana, and in Fitzgerald, Georgia.

After a year at the University of Georgia in Athens, he transferred to Wooster University, Wooster, Ohio, and was graduated in 1909 with a B.A. degree. As previously indicated, he continued his studies at Harvard Law School, graduating in 1913 with an LL.B. degree.

In 1933, he was elected to the presidency of The First National Bank of Great Falls, resigning in 1936 to become the general counsel of Montana Power Company. Also, in that year he began his long and eventful association with Anaconda Copper Mining Company.

During World War I, Harold served as a private in the United States Army. In 1924, he was a delegate from Montana to the Republican National Convention in Cleveland.

The lure of Montana's farms and ranches was in his blood and, at every opportunity during vacation periods throughout his school and college years, Harold returned there to work in a variety of jobs. In 1921, he bought a cattle ranch near Belt, Montana. Four years later, he began to raise registered Hereford cattle. Ever since, he has continued this activity and the breeding and raising of pedigreed Herefords is still one of his major hobbies.

Mr. Hoover is a member of the board of directors of The National City Bank of New York; The First National Bank of Great Falls; Anaconda Wire & Cable Company; Butte, Anaconda & Pacific Railway Company; Butte Water Company; Andes Copper Mining Company; Chile Copper Company; Chile Exploration Company; Chile Steamship Company, Inc.; Green Cananea Copper Company; The American Brass Company; and International Smelting and Refining Company. Also, he is a member of the board of trustees of Roosevelt Hospital, New York City.

Harold holds memberships in the American Bar Association, Montana Bar Association, National Association of Manufacturers, Great Falls Chamber of Commerce (a former president), Kiwanis International (a former district governor), Clove Valley Rod & Gun Club, Sleepy Hollow Country Club, India House, The City Midday Club, and The Recess Club.

William Harold Hoover married Grace M. Young, June 15, 1915, in Cleveland, Ohio. They have one child, an adopted son, John M. Hoover. The family home is at 1039 West Broadway, Butte, Montana.

Harold has been an enthusiastic hunter and fisherman since boyhood days. In recent years, because of the demands of his business affiliations, he limits his field and stream activities to week-end expeditions, with fellow members of the Clove Valley Rod & Gun Club in its outdoor preserves in New York's Duchess County, and visits to his ranch in Montana.

Editorial

Defense Production Act of 1950
Status of Government Aid Program

Senator Joseph C. O'Mahoney, Wyoming, chairman of the Interior and Insular Affairs Committee, issued a memorandum recently to explain the reasons for delay by the Government in making financial aid available for the encouragement of mining under the Defense Production Act of 1950. Although the Defense Production Act was approved September 8, 1950, authorization for loans and grants was not effective until the Excess Profits Tax Act was passed on January 3, 1951. This was because under the Internal Revenue Code all those who received loans, or other payments for the encouragement of mining, were required to report them as gross income in their tax returns. The Act of January 3, 1951, exempts from gross income such loans or other payments made by the Government for defense purposes.

An organization of 80 field examiners has been set up and is operating out of the regional headquarters of the U. S. Bureau of Mines, in Denver, to examine the properties of applicants under the provisions of Sections 302 and 303 of the Defense Production Act. This law authorizes the President to make loans and to give other aid to private businesses to help to stimulate the exploration, development, and mining of strategic and critical metals and minerals. New application forms for loans and other types of aid are in preparation. Also, a small-mine aid program is expected to be ready by the time mining operations can be started in the spring of 1951.

Only seven contracts had been made with domestic corporations at the time the memorandum was issued late in January, but many more applications were being processed. It was predicted that in the near future a substantial number of mining enterprises should be receiving government support so that, to the fullest extent possible, supplies of strategic and critical metals and minerals within the United States will be available.

The Defense Minerals Administration is headed by Dr. James Boyd, director of the United States Bureau of Mines. According to Dr. Boyd, this administration has three principal objectives: first, to maintain production from existing sources of mineral supplies; second, the expansion of production from known but practically inactive sources; and third, the encouragement of exploration and development of new sources, particularly in the continental United States.

Department of Defense
Notes on Mobilization

From the Office of the Secretary of Defense comes the following information: John D. Small, chairman of the Munitions Board, has urged the Army, Navy, and Air Force to speed up contracts, especially for those major items which require a long time to produce. The Munitions Board has been strengthened by reorganization and by placing more top business men on the staff. A major change was the setting up of a separate office for stock-pile management, to handle stock-piling programs and operations. Roscoe Seybold, former vice president of Westinghouse, is in charge of this office, as vice chairman.

The question of allowing accelerated depreciation resulting from abnormally intensive use of equipment in emergency production is being given consideration by the Munitions Board and the military departments.

In expanding current procurement in preparation for possible full industrial mobilization, a critical analysis is being made to determine the possibility of changing specifications to permit the use of substitutes for critical materials wherever possible.

New Estimates on Coal Reserves

In a progress report on its studies to determine the coal reserves of the United States, the Geological Survey announces that we have 1.2 trillion tons that are recoverable, and that about 30% of this tonnage is economically recoverable. The report indicates that this vast reserve comprises about 50% bituminous coal, 19% subbituminous, 30% lignite, and 1% anthracite.

"Despite the relative increase in the use of other fuels during the last 30 years," reports Secretary of the Interior Chapman, "coal remains one of the foundations of our national security in its contained reserves of energy. Although we are fortunate to possess this great resource, prudence dictates that it be mined with maximum efficiency; that the different ranks and qualities of coal be used for the purposes to which they are best suited; and there continues to be a stable and flourishing coal-mining industry."

The report contains much statistical information by states and by ranks of coal. It may be obtained from the Geological Survey by asking for "Circular 94—Coal Resources of the United States, a Progress Report, November 1, 1950."

DRILLING BLAST HOLES: After a face has been undercut, two men start drilling eight holes 7 ft. deep into the coal for blasting with 1¼ by 8-in. cartridges of Hercules Red H F permissible powder.

MINING KENTUCKY COAL FOR International Harvester Company

An abandoned mine at Benham was reopened and is being operated successfully through skillful applications of modern equipment and techniques

R. L. TALBERT*

THE Wisconsin Steel Coal Mines at Benham, Harlan County, Kentucky, a subsidiary of International Harvester Company, ships most of its production of local coal to the Harvester Company's steel mill in Chicago, Illinois, where it is processed in a coke and by-products plant. The coke is used in making steel for all Harvester Company products.

The underground mining of coal at Benham was begun in 1910, when the driftmouth at No. 1 mine was opened in the Benham Spur region of Black Mountain. The mine was operated continuously from that time until its closing in October, 1948. Another underground operation, designated as No. 2 mine, was opened in the Looney Ridge section in 1918. It was located to the north of No. 1 mine and separated by a valley in which the community of Benham was built. After being operated for a period of eight years, this mine was closed in 1926.

During and immediately following World War II years, the company's operating management at Benham made a study of the Looney Ridge territory to determine whether or not the old No. 2 mine could be reopened and mined successfully. It was known that the boundary of No. 2 mine still contained a sizable reserve of "C" seam coal, with excellent properties for metallurgical purposes. It was decided to reopen the mine and to convert operating and producing methods from the old hand-loading method to modern mechanization techniques. After inspecting various mechanical equipment and visiting a number of mechanized mines, it was finally decided to install shaker conveyors and rubber belts in the mine. Many factors were given careful consideration, including the immediate draw-rock overlying the coal seam which would necessitate close, heavy timbering.

The overburden in the area of the No. 2 mine ranges in thickness from approximately 500 to 1,100 ft. Directly over the coal, the roof stratum consists of a layer of poorly laminated slate and shale, from 18 to 48 in. thick. It tends to separate from the sandstone main roof very soon after the coal face is undercut. The "C" seam, averaging 60 in. in thickness, is exceptionally clean. The bottom consists generally of fire clay, soft in some places in the mine and fairly hard in others. The Kentucky Department of Mines and Minerals classifies the mine as nongassy. Methane has never been detected in return air samples in excess of the limits set

*Acting Safety Supervisor, Wisconsin Steel Coal Mines, International Harvester Co., Benham, Kentucky.

LOADING DYNAMITE CHARGES: The eight drill holes in the coal working face are loaded with 1¼ by 8-in. cartridges of Hercules Red H F permissible powder. The primer cartridge is always inserted first in each drill hole, with the "business end" of the electric detonator pointing toward the remainder of the explosives charge. Each loaded hole is tamped to the collar with rock-dust dummies.

BLASTING RESULTS: Blasts in the working faces yield approximately 52 tons of coal in each cut, representing a ratio of about 6.1 tons of coal per pound of explosives. A substantial percentage of block and egg coal is generally obtained from the blasts.

by both the State Department and the U. S. Bureau of Mines.

Retraining Employes

In February, 1947, the "B" seam, approximately 30 ft. under the "C" seam, was opened and entries for haulage were driven directly under the projected "C" seam workings. When No. 1 mine was closed in October, 1948, a fairly abrupt change was made for the majority of men from hand-loading to conveyor loading. This change, of course, created problems and the supervisory organization was immediately faced with the job of retraining employes in a different method of work. Many of the men had never seen the mechanical equipment that was introduced and, naturally, they were inexperienced in its operation and with its capabilities. The training program was immediately undertaken, and in the ensuing months, the situation improved tremendously. Realizing that such a problem will be a continuous one, the management plans to continue the crew training. In all probability, this will take the form of time studies, proper work methods to integrate production and safety, and individual training for the operators of various types of equipment.

The face equipment in a typical working room consists of a shaker conveyor with an overlapping right-angle turn assembly, a permissible shortwall cutting machine, a permissible hand-held drill, steel screw jacks for use at the face, and extra pan material to be added as the room advances. Normally, a crew of five men works in each room. As the working place advances, the roof is supported with 4 by 8-in. by 14-ft. wooden cross-collars set on approximately 2-ft. centers. As sufficient coal is loaded out for clearance, these cross-collars are set in place on steel jacks, and wooden posts are then set under the bars.

Rooms are turned at right angles to the butt entries on 72-ft. centers and are driven 36 ft. wide to their limit of 250 ft. The 36-ft. pillar is then extracted in its entirety.

The Work Cycle

The work cycle begins with the operation of a Jeffrey 35 BCS shortwall undercutting machine, with an 8-ft. cutter bar to cut the face. As soon as there is sufficient room, two other mem-

AFTER A BLAST: The blasted coal is transported from the face to the butt entry by a shaker conveyor with an overlapping right-angle turn assembly. The conveyor discharges onto a 30-in. rubber belt.

bers of the crew start behind the machine operators and drill eight 7-ft. holes into the face. The fifth man in the crew is usually busy setting wooden legs under the cross-collars, originally supported on steel jacks. After finishing the timbering, he begins dusting out the undercut face as the machine crew finishes the cut. The two men drilling proceed across the face close behind the machine crew. As soon as the face is undercut, the Jeffrey machine is pulled to the right rib of the working place and the operators disassemble the overlapping right-angle turn so it can be moved to the face. The two drillers help with this operation after they have finished drilling. The four men move up the face and add pans to the room pan-line as needed, and assemble the overlapping right-angle turn so that the face pan is only about 1 ft. from the freshly undercut face. While the pan-line is being assembled, the fifth man finishes dusting the undercut and proceeds to the section storage magazines for the required number of cartridges of permissible powder, the detonators and the dummies.

The four rib holes and two bottom, or snubber, holes toward the center of the face are then loaded with four 1¼ by 8-in. cartridges of Hercules Red H°F permissible powder. The two top holes toward the center of the face from each rib are loaded with five cartridges of Red H F.[1] The primer cartridge is inserted first in each hole, with the "business end" of the electric detonator pointing toward the remainder of the charge. Each loaded hole is tamped to the collar with rock-dust dummies. When all necessary "deadwork" is completed, the pan-line is started, the crew evacuates the working place, and at least one man guards each entrance to the place. The two bottom, or snubber, holes are fired singly by means of a permissible shot-firing device on the cap-lamp battery. The two top holes are then fired singly and, finally, the four rib holes are fired

(Continued on page 26)

ROOF SUPPORT: As a working place advances, the roof is supported with wooden cross-collars set on approximately 2-ft. centers. The cross-collars are subsequently set on steel jacks.

°Reg. U. S. Pat. Off.

THE AWARD: T. C. Thielman, general superintendent of Pickands Mather & Company's East Mesabi district, accepts the award of the trophy from J. I. Horty, managing editor, The Explosives Engineer.

Pickands Mather & Company Honors Embarrass Miners

Sentinels of Safety trophy awarded to the winners in the open-pit mines group in the 1949 National Safety Competition

IMPRESSIVE ceremonies were held on the grounds of Pickands Mather & Company's Embarrass mine, Biwabik, Minnesota, August 15, 1950, to mark the formal award of the Sentinels of Safety trophy and flag to the mine employes for winning top honors in the open-pit mines group in the 1949 National Safety Competition. Approximately 300 company officials, employes, and guests participated.

R. F. Kohn, superintendent of Embarrass mine, was master of ceremonies. He extended his congratulations, as well as those of the local supervisory force, to the winning miners and expressed gratitude to the management personnel and his fellow-workmen for their splendid cooperation in making the mine a safe place in which to work. He then introduced Joseph I. Horty, managing editor of THE EXPLOSIVES ENGINEER, who made the official award of the Sentinels of Safety trophy and flag.

In his remarks, Mr. Horty brought out the fact that the 1949 National Safety Competition marked the 25th anniversary of this nation-wide project. "In the first contest 25 years ago," he said, "there were 200 plants enrolled. None of them worked through the year 1925 without a lost-time injury. In 1949, there were 646 mines and quarries participating, and 202 of them did not have a single lost-time accident during the entire year.

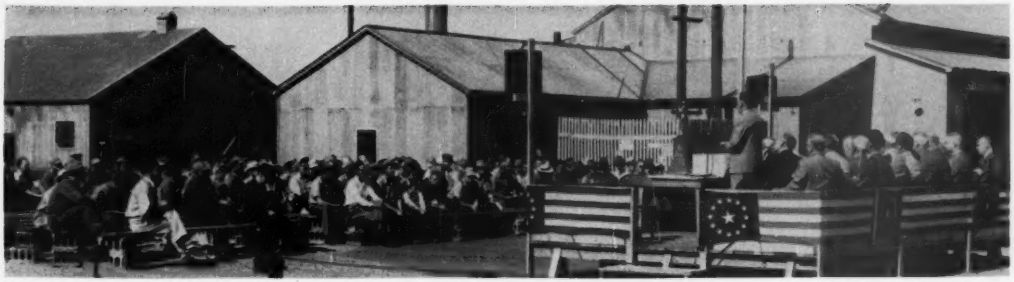
"There were 30 open-pit mines that reported injury-free records in 1949," continued the speaker, "but the record of 596,879 man-hours at Embarrass mine was the best record of all. You men are deserving of sincere congratulations on this magnificent accomplishment in safety on the job."

In addition to the trophy, Mr. Horty awarded a Sentinels of Safety flag to the mine with the hope that it will be flown over the property and be an incentive to all to keep up the good work of maintaining safe operations.

T. C. Thielman, general superintendent of the East Mesabi district of Pickands Mather & Company, accepted the trophy and flag on behalf of his associates. After thanking the miners for their splendid achievement, he said, "In winning this award, three of the most important things manifested were, in my opinion, the spirit, the enthusiasm, and the whole-hearted cooperation of you men in carrying out company safety rules in the mine."

After reading a telegram of congratulations from Elton Hoyt, second senior partner in Pickands Mather & Company, Mr. Thielman asked Ben Constantine, chairman of the Employes' Safety Committee, and John Erickson, chairman of the Foremen's Safety Committee, to comment on the award. "Each day we go to our work," said Mr. Constantine, "with the thought that we have families at home whom we love and cherish, and we want to come home safe to those families." Mr. Erickson thanked each miner for his efforts to work safely. He recalled that on December 31, 1949, "we gave very special instructions to everyone to be extra careful. We were almost afraid to open or close a door for fear of hurting someone and spoiling our perfect record."

John A. Johnson, district engineer for U. S. Bureau of Mines, was next called upon by Mr. Kohn, and he presented Certificates of Achievement in Safety, signed by Dr. James Boyd, the director of the Bureau, to each man in the mine organization. In his remarks, Mr. Johnson commented upon the fact that the Sentinels of Safety trophy had been won by a Pickands



TYPICAL SCENE: A part of the group of miners, company officials, and guests as they listened to T. C. Thielman's congratulatory remarks.

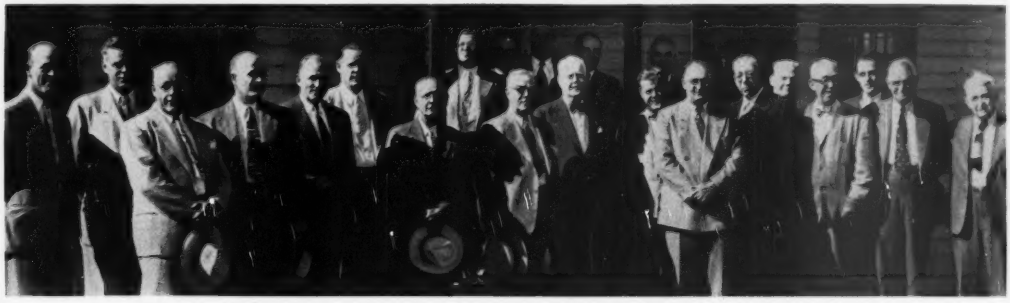
STOP, LOOK, LISTEN: "On December 31, 1949, we were almost afraid to open or close a door for fear of hurting someone and spoiling our perfect record," said John Erickson, chairman of the Foremen's Safety Committee.

Mather mine 12 times since the company entered the National Safety Competition in 1930. He also pointed out that one of the ore mines in the Minnesota and Michigan districts had been the winner of the trophy in 20 of the 25 annual contests.

A. D. Chisholm, general manager of Pickands Mather & Company, was the next speaker. After saluting the men for their victory, he said, "I like to compare the employes of Embarrass mine with the college all-star football players who recently beat the country's top professional team in the annual game at Chicago. Like the college players, you have demonstrated the value of teamwork and coordinated effort. We're all proud of you." The speaker concluded his remarks by extending congratulations to the Embarrass miners from Mr. Block of Inland Steel Company, Mr. Mauthe of Youngstown Sheet and Tube Company, and Mr. Peterson of Bethlehem Steel Company.

E. J. Fearing, the company's general superintendent in the Hibbing district, spoke of his pride in having had a part in the victory—he was general superintendent of the mines in the area during the time that the trophy was earned and won. "As Mr. Chisholm has said, you're a fine ball team. Go out and win the contest again."

The program was brought to a close by the raising of the Sentinels of Safety flag under Old Glory, by C. A. Helmer, safety inspector for the company in the East Mesabi district, assisted by Ervin Kieren, chief clerk in the mine office. As the flag was attached, the bugle call "To the Colors" was sounded by Elmer Beck, a member of the mine's office staff.



END OF THE DAY: When the ceremonies were over, some officials and guests of Pickands Mather & Company posed for the photographer in front of the mine office at Biwabik, Minnesota.

Blasting Vibrations' Effects

L. DON LEET*

Practically everything that moves generates elastic vibrations, physically the same as those generated by blasting with explosives

PART II

EARTH waves from blasting normally range in frequency from about 3 to 50 cycles per second, depending on the types of rock or earth and the size of the blast. Surface waves are seldom of higher frequency than 10 to 15 cycles per second in any material. If such waves could be photographed (they cannot, because of their microscopic heights), they would be found crenulating the surface in a manner not unlike that of waves on water. Their wave lengths, or distances from crest to crest, range between about 100 ft. and 1,000 ft.

The earth waves which are of primary interest from the standpoint of effects on structures are the surface waves, which carry over 95% of the energy at points more than a few feet from a blast. As they pass a house or other structure, they cause the foundation to move just as earth particles in their path. These movements were described in defining the different wave types. This motion is usually sufficiently rapid to make it difficult for the building's superstructure to follow exactly, owing to its inertia. As a result, strains are set up in the building. They are essentially the same as they would have been had the foundation been clamped firmly while only the superstructure moved. This latter condition obtains during a strong wind.

When an earth wave 300 ft. from crest to crest passes a 30-ft. house, the house moves as a unit, as would a large, slightly flexible crate on an ocean wave. If it were large enough to cause damage, the effects would be observed throughout the building. This mechanism by which earth waves affect buildings is quite different from that involved in some "popular" ideas that vibrations from the ground hit the side of a building like a missile, or run hither and yon along the frame members, hitting an occasional plaster panel like the blow of a hammer.

Nature of the Terrain

The actual amount of motion imparted to a building by an earth wave depends in part upon the nature of the terrain at the point in question. This arises from the different ways in which earth materials respond to applied force. For example, a shove of one pound per square inch on a sand mass would distort it more than the same force applied to a mass of granite. As a result, an earth wave as it moves across the surface, transmitting its energy from point to point, will cause granite in its path to yield or be displaced less than, say, sand at the same point under the same elastic force. This situation leads to a spotty distribution of damage frequently observed in the region of a strong earthquake. In the vicinity of Tokyo on September 1, 1923, some structures on deep alluvial ground were much more severely shaken than others many miles closer to the source, but resting on rock.

These differences in responsiveness of earth materials have been evaluated in general terms and are described by what may be called a *terrain coefficient*. If the shaking produced by a wave at a given point on rock is assigned a coefficient of 1, it has been observed that the same wave at the same point would shake or displace a structure on average overburden (not more than ¼ to ½ wave length's thickness of soil over rock) 10 times as much. Accordingly, normal overburden can be said to have a terrain coefficient of 10. Abnormally deep overburden, ¼ wave length or more in thickness, of water-soaked sand and

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loam may have a terrain coefficient as high as 30.

This terrain coefficient should not be confused with the effect of different earth materials in damping out or absorbing energy as a wave travels along the ground. If a wave travels 1,000 ft. in abnormally deep overburden, it will, at the end of that travel, possess considerably less of its original energy than it would at the end of a course of 1,000 ft. in granite. At the end of the 1,000-ft. journey, however, no matter what its past history, the wave will produce a greater displacement in abnormal overburden than in rock at the same point, as indicated by the respective terrain coefficients.

The U. S. Bureau of Mines developed an empirical formula that expresses the maximum amplitude of vibration in terms of weight of explosive charge and distance, for average overburden, where the explosive is detonated simultaneously. The formula is:

$$A = \frac{C^{2/3}}{100}(0.07e^{-0.00143d} + 0.001)$$

where A = maximum resultant amplitude in inches

C = explosive charge in pounds

d = distance in feet

e = base of natural logarithms (2.72)

The limits of the formula are:

Charge	Distance
1,000 – 15,000 lbs.	500 – 6,000 ft.
100 – 1,000 lbs.	100 – 6,000 ft.
10 – 100 lbs.	100 – 1,000 ft.

The numbers given by this formula are to be divided by 10 for rock outcrops and multiplied by 3 for abnormally thick overburden. They have been checked extensively by the Bureau of Mines, as well as by many independent investigators, and found to be highly accurate within the limits needed for practical engineering purposes. Table I gives figures computed from this formula.

The displacements of Table I are produced when the explosive is detonated essentially simultaneously. Techniques have been developed by which the vibration from a given total amount of explosive is appreciably reduced. These involve what is known as Short-Period Delay blasting, which has been developed since 1945.

TABLE I–Displacement[1] for Various Weights of Explosives, Inch

Weight of explosives pounds	*Distance from Blast, Feet*								
	100	200	300	400	500	600	700	800	900
10	0.0029	0.0025	0.0022	0.0019	0.0016	0.0014	0.0013	0.0011	0.0010
20	.0045	.0039	.0034	.0030	.0026	.0023	.0020	.0017	.0015
30	.0059	.0052	.0045	.0039	.0034	.0030	.0026	.0022	.0020
40	.0072	.0063	.0054	.0047	.0041	.0036	.0032	.0027	.0024
50	.0084	.0073	.0063	.0055	.0048	.0042	.0037	.0032	.0028
60	.0095	.0082	.0072	.0063	.0054	.0047	.0042	.0036	.0031
70	.010	.0091	.0079	.0069	.0060	.0052	.0047	.0039	.0035
80	.011	.0099	.0086	.0075	.0065	.0057	.0051	.0043	.0038
90	.012	.011	.0093	.0081	.0070	.0061	.0055	.0046	.0041
100	.013	.012	.010	.0087	.0076	.0066	.0059	.0050	.0044
200	.021	.018	.016	.014	.012	.010	.0094	.0079	.0069
300	.028	.024	.021	.018	.016	.014	.012	.010	.0091
400	.033	.029	.025	.022	.019	.017	.015	.013	.011
500	.039	.034	.029	.026	.022	.019	.017	.015	.013
600	.044	.038	.033	.029	.025	.022	.019	.016	.014
700	.049	.042	.037	.032	.028	.024	.022	.018	.016
800	.053	.046	.040	.035	.030	.026	.024	.020	.017
900	.057	.050	.043	.038	.033	.029	.026	.022	.019
1,000	.....	.....	.....	.....	.035	.031	.027	.023	.020
2,000	.....	.....	.....	.....	.056	.049	.044	.037	.032
3,000	.....	.....	.....	.....	.073	.064	.057	.048	.042
4,000	.....	.....	.....	.....	.089	.078	.069	.059	.051
5,000	.....	.....	.....	.....	.10	.090	.080	.068	.059
6,000	.....	.....	.....	.....	.12	.10	.090	.076	.067
7,000	.....	.....	.....	.....	.13	.11	.10	.085	.074
8,000	.....	.....	.....	.....	.14	.12	.11	.093	.081
9,000	.....	.....	.....	.....	.15	.13	.12	.10	.088
10,000	.....	.....	.....	.....	.16	.14	.13	.11	.094

Weight of explosives pounds	*Distance From Blast, Feet*					
	1,000	2,000	3,000	4,000	5,000	6,000
100	0.0038	0.0011	0.0004	0.0003	0.0002	0.0002
200	.0060	.0017	.0007	.0004	.0003	.0003
300	.0079	.0022	.0009	.0005	.0004	.0004
400	.0096	.0027	.0011	.0006	.0005	.0005
500	.011	.0032	.0013	.0008	.0006	.0006
600	.013	.0036	.0014	.0009	.0007	.0007
700	.014	.0039	.0016	.0009	.0008	.0008
800	.015	.0043	.0017	.0010	.0009	.0009
900	.016	.0047	.0019	.0011	.0009	.0009
1,000	.018	.0050	.0020	.0012	.0010	.0010
2,000	.028	.0080	.0032	.0019	.0016	.0016
3,000	.037	.010	.0042	.0025	.0021	.0021
4,000	.045	.013	.0051	.0030	.0025	.0025
5,000	.052	.015	.0058	.0035	.0029	.0029
6,000	.058	.016	.0066	.0040	.0033	.0033
7,000	.065	.018	.0073	.0044	.0036	.0036
8,000	.071	.020	.0080	.0048	.0040	.0040
9,000	.076	.022	.0086	.0052	.0043	.0043
10,000	.082	.023	.0093	.0056	.0046	.0046

[1]Amplitudes are for average overburden. From Bulletin 442, U. S. Government Printing Office, Washington, 1942. For outcrops divide amplitude by 10. For abnormal (deep or sand-gravel-loam) overburden multiply by 3. These are maximum amplitudes resulting from instantaneous detonation of explosive.

Long-Period Delay Blasting

For many years, the explosives industry has supplied delay blasting caps for use in special types of tunnel and mine blasting. When firing current is applied to a series of such caps, the zero type detonates at once; the first delay, from 1 to 1½ seconds later; and so on. The exact interval varies sometimes by an appreciable percentage of the average for a given type of delay.

Vibrations from long-period delay shooting have been studied. Under conditions of rock outcrop or relatively thin overburden, the vibration pattern from explosives detonated at one delay interval is completed before that from

FIGURE 5: Plan view and section of a quarry face, showing a method of using 12 Short-Period Delays progressively in a single row of drill holes. This method greatly minimizes vibration.

another begins. In that way, there is no overlapping to permit either interference or combination of waves. In one test, when a quarry loaded a total of 22,300 lbs. of dynamite and fired it with delay caps initiating groups of 5,950, 5,550, 6,100, and 4,700 lbs., the vibrations at a test point were separated in such a way that their effect on the neighborhood was the same as it would have been had the individual groups been detonated a day or a month apart. There was no fundamental reduction of vibration, however, because 6,100 lbs. or 4,700 lbs. produced the same vibrations, whether fired as single shots or as parts of a long-period delay series. (See "Vibrations From Blasting," by L. Don Leet, THE EXPLOSIVES ENGINEER, pp. 57-61, March-April, 1944.)

Short-Period Delay Blasting

Short-period in this connection means a time interval of a few thousandths of a second. Since one-thousandth of a second is one millisecond, the term millisecond delay is sometimes used. Firing of different holes a few milliseconds apart has been accomplished by the use of specially constructed electric blasting caps which detonate at different times, or by special switches which apply the current to standard blasting caps at the desired intervals. For example, Hercules Powder Company manufactures No Vent* Short-Period Delays SP-1 through SP-12 which fire after intervals of approximately 25, 50, 75, 100, 135, 170, 205, 240, 280, 320, 360, and 400 milliseconds. The longest interval, 400 milliseconds, is 4-tenths of a second (0.4 sec.). If each hole of a single row of 12 drill holes, like those shown in Figure 5, is primed with a different short-period delay, only one hole fires at a time. The intervals between these delays are so small that before the broken mass of rock has a chance to topple over, adjacent holes are detonated. Thus, as each hole partially relieves its unfired neighbor, the impacts from adjacent holes tend to counteract each other, and the rock is removed from the face by shearing action instead of being kicked out all at once as by an instantaneous blast.

Figure 6 shows the firing of a short-period delay blast. At the instant of the photograph, all holes had detonated but it can be seen clearly that though the face is broken, it is just starting to fall. As the fracturing is initiated progressively, the expanding gases from each hole, in addition to starting some new fracturing, work into the partially broken material adjacent, and greatly improve fragmentation. Experience has shown that this and other applications of short-period delay blasting improve fragmentation, reduce backbreak and endbreak, and spectacularly reduce vibration in the vicinity. Vibrations are waste by-products of blasting energy, and when small they indicate efficient use of the explosive force doing its main job—breaking rock.

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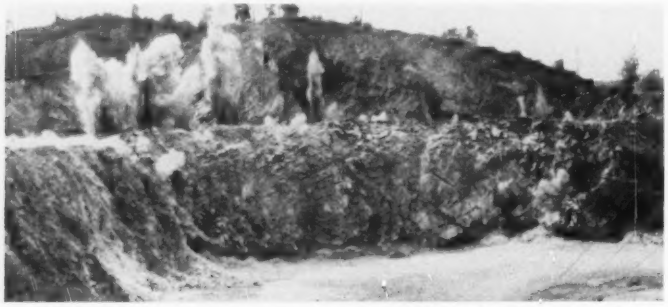

FIGURE 6: Photograph of a blast in a quarry, in which Short-Period Delay Electric Blasting Caps were used to detonate the charges of explosives.

Figure 7 shows seismograph records taken at the same location 4,500 ft. from each of two shots. The bottom record represents the vibrations from a 2-hole instantaneous shot of 2,080 lbs. The top record shows the vibrations at the same point from a shot in the same quarry of 17,591 lbs. in 7 holes fired in sequence, from 1 through 7, at intervals of 20 milliseconds. The character of the motion in each case was similar, and the maximum displacements were equal.

Figure 8 gives the results of two other tests at 2,400 ft. from the same quarry. The bottom record shows vibrations from a 3-hole delay shot of 12,000 lbs., while the top record shows vibrations from a 12-hole delay shot of 37,772 lbs. Maximum displacement from the 3-hole shot was 11-thousandths of an inch (.011 in.) and from the 12-hole shot it was 8-thousandths of an inch (.008 in.). This phenomenon, observed in a number of tests, has led to the conclusion that there is an optimum number of holes which gives best results with short-period delay blasting. The amount of explosives per hole is naturally a factor, but the observation remains that at least 2-hole and 3-hole delay shots do not yield the greatest possible reduction in vibration. Whether the optimum is 4-, 5-, 6-, 7-hole or more depends on the location, burden, spacing, and type of rock. Burden and spacing, of course, are determined by the type of material and purpose for which the blasting is done.

A striking feature of the results of tests of this kind has been that arbi-

trary reduction in number of holes or pounds of explosives does not automatically reduce the magnitude of vibrations.

Airborne Waves

Detonation of a buried explosive, in addition to shattering surrounding ground and causing elastic waves in nearby earth materials, sometimes sets up a concussion in the air. This travels away from the source in the form of a push, or compressional, wave in air. It is independent of the sound wave that carries any of the noise involved.

The U. S. Bureau of Mines (Reports of Investigation 3622 and 3708, "Damage From Air Blasts," 1942 and 1943) has investigated the form of this wave and the magnitude and effects at various distances from standard quarry shots, blockhole shots, and seam shots, as well as the effects of firing dynamite in the open air.

The pressure due to a normal wind on a plane surface is as shown by the equation

$$P = 35 \times 10^{-6} V^2$$

where P is the pressure in lbs. per sq. in. and V is the wind velocity in miles per hr. From this, a 100-mile-per-hr. wind will produce a pressure of .35 lb. per sq. in. In the construction of buildings. it is common practice to assume a steady wind pressure of .21 lb. per sq. in. for design purposes. Some velocities and corresponding pressures are listed below:

V (mi./hr.)	P (lb./sq. in.)
169	1.000
100	.350
50	.088
25	.022
10	.0035
5	.0009

Ordinary conversational speech at 2 in. will develop about .00009 lb. per sq. in.; public speech will produce .0004 lb. per sq. in.; and accented syllables, especially around election time, may reach peak values of .0011 lb. per sq. in.

Air Blasts Crack Glass

In order to investigate air blasts strong enough to crack glass, the Bureau of Mines found it necessary to use charges fired in the open air. They found that the manner in which glass is mounted in its frame influences its resistance to concussion somewhat, but, in general, it is necessary to subject normal window glass in small lights to pressures of between 1 and 2 lbs. per sq. in. to be sure of breaking it. The pressure of 1 lb. per sq. in. was associated with conditions of poor glass mounting and entailed minor failure; the pressure of 2 lbs. per sq. in. is taken as the point at which definite failure can be expected. *It is particularly significant that window glass failure occurred before any other structural failure.*

In contrast to these figures, the air blast resulting from the blockhole and well-drill quarry shots produced maximum pressures of the order of .01 lb. per sq. in. or less at short distances. Air blast from seam shots produced maximum pressures of the order of 0.1

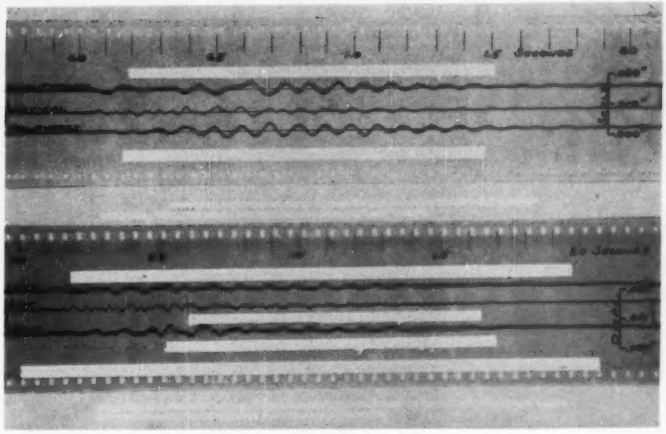

FIGURE 7: Top record: Vibrations in a kitchen at a distance of 4,500 ft. from a 7-hole delay blast of 17,591 lbs. of dynamite.
Bottom record: Vibrations in the same kitchen from a 2-hole delay blast of 2,080 lbs. of dynamite.

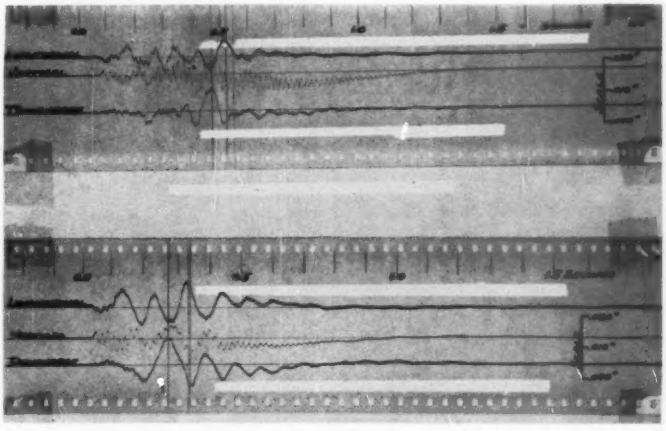

FIGURE 8: Top record: Vibrations at 2,400 ft. from a 12-hole blast of 37,772 lbs. of dynamite.
Bottom record: Vibrations at the same point from a 3-hole delay blast of 12,000 lbs. of dynamite.

lb. per sq. in. The maximum pressures resulting from well-drill shots of 4,000 lbs. of explosives were of the same magnitude as the pressures from 10-lb. blockhole shots. The Bureau of Mines further reported: "It was not possible to obtain window glass failure from air blast with either well-drill or blockhole shots. Experimental window boxes were taken as close as possible without encountering damage from flying or moving rock."

In other words, commercial blasting causes air pressures even at closest ranges, which are measured in 1 to 10 units (at most, 100 from relatively rare seam shots), where 1,000 to 2,000 units are necessary to cause glass damage, which must occur before any other from this cause. Pressures from the great majority of commercial blasts are in the range of those from a light summer breeze at most places in the neighborhood.

Atmospheric Conditions

In spite of the obvious absurdity of fearing or alleging property damage from these miniscule forces, experience has shown that the pattern of distribution of airborne concussion and noise around a blast may have more effect on the number and location of complaints than actual ground motion does. Airborne effects are influenced by wind direction and velocity. Wave fronts headed into a wind will be so bent as to curve upward and skip entire regions nearby by passing overhead. With the wind, they may be curved in the opposite direction in such a way as to be observed on the opposite side of a hill which would otherwise block it. Figure 9 illustrates this.

Other atmospheric conditions, such as unusual temperature distribution, or low cloud ceilings lead to the erratic spread of airborne concussion and sound. People who rely upon sound or airborne concussion for knowledge that a blast has been fired will then be equally erratic in making complaints. Meanwhile, the ground vibrations are completely unaffected by atmospheric conditions and are nearly constant from year to year about a quarry unless major changes in blasting procedure are made.

The sharp crack of uncovered Primacord is a source of noise that may startle a person, though it cannot produce damage any more than the crack of a pistol shot or a firecracker.

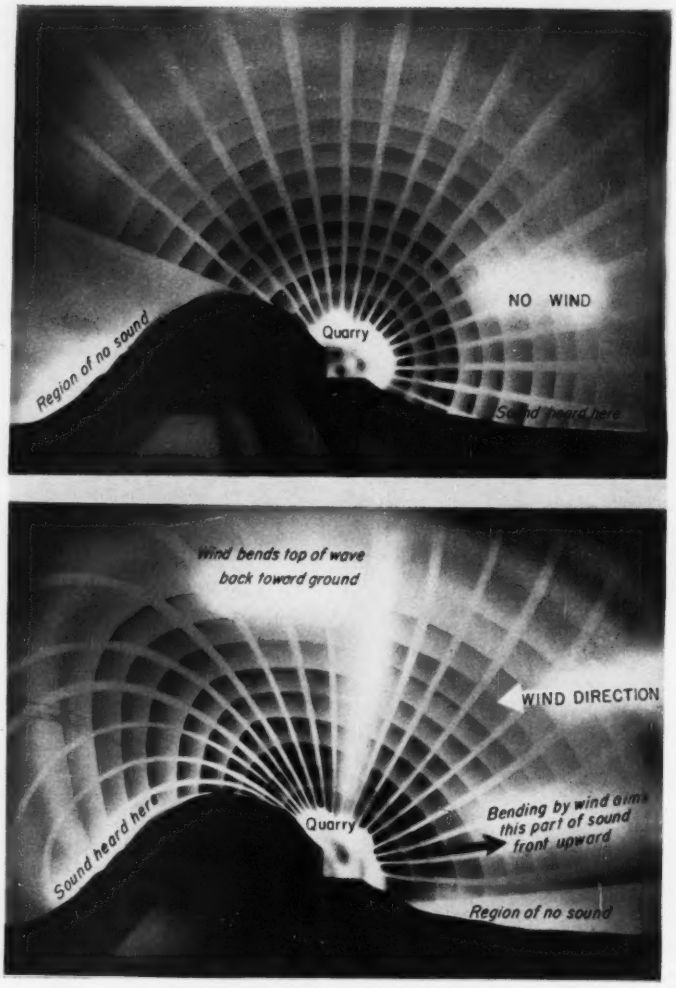

FIGURE 9: The effects of wind on audibility of sound from a quarry blast. Airborne effects are influenced by wind direction and velocity. Wave fronts headed into a wind will be bent to curve upward and skip entire regions nearby by passing overhead. With the wind, they may be curved in the opposite direction and be observed on the opposite side of a hill, which otherwise would block them.

The end of World War II was hastened by military application of atomic bombs on the Japanese cities of Hiroshima and Nagasaki. Worldwide attention and discussion were centered on the fantastic devastation accomplished by these bombs. In this connection, it should be noted that destruction was entirely by airborne radiation and concussion combined with fires started by the intense heat. The bombs were deliberately detonated well above the ground to accomplish this. These results have no bearing on the effects of detonating confined charges of ordinary explosives, or even a buried atomic bomb.

(To be continued.)

BLASTING ROCK CUTS

ON HEAVY-CONSTRUCTION PROJECTS

Short-Period Delay Electric Blasting Caps contribute to the control of rock breakage and minimize backbreak and high-bottom rock between blasts

A. BRUCE LATTANZI*

DURING the past five years, Walter Dunham, president of Cabot Construction Company and of Rock Construction Corporation, Kingston, New York, has concentrated his efforts and those of his associates in subcontracting the drilling and blasting of rock formations on various heavy-construction projects in eastern states. At present, they are busy on a subcontract at the Downsville Dam project, Downsville, New York, requiring the drilling and blasting of 560,000 cu. yds. of rock in a weir 870 ft. long and 100 ft. deep, and in a waste channel 1,370 ft. long and 175 ft. deep; the sinking of a shaft and the driving of a tunnel; and the placing of 40,000 cu. yds. of dry paving on the upstream face of the Downsville Dam.

The bedrock formations at Downsville are sediments, belonging to the Catskill series of sandstones and shales. Horizontally bedded, they show practically no effects of dynamic metamorphism, since they have never been folded except at the extreme eastern edge. Igneous activity has not affected the bedrock formations, and there are no dikes or intrusions.

The sandstone on the job is of the graywacke type. The grains are compound grains, made up of fragments of other rocks rather than comprising quartz and feldspar grains. The beds vary in thickness, with a few being of the flagstone type. However, they are unsuitable as flagstone because of many irregularities, such as cross-bedding. A few beds are of the thick bluestone type, some of which could be cut for use as dimension stone. Most of the sandstones are gray; some have a faint bluish, greenish, or reddish tint.

Most of the shales are of the thinly laminated variety; some are irregular and gnarly. Mechanically weak, they

AT DOWNSVILLE: This view, looking upstream from the shaft site to the weir, is typical of Rock Construction Corporation's open-cut excavation activities at the Downsville, New York, dam project. The subcontract calls for drilling and blasting 560,000 cu. yds. of rock.

DRILLING: Crews at work with wagon drills putting down holes on 6-ft. centers, for blasting in the 100-ft. deep, 870-ft. long weir section.

*Engineer, Rock Construction Corporation, Downsville, New York.

HIGH WALL: The walls in the weir and waste channel sections have to be carefully line drilled because of poor rock conditions.

"GLORY HOLE": Looking upstream on the Downsville job, from the waste channel across the glory hole to the weir section.

COMPRESSORS: Air for the drills is supplied by four 630D Joy Compressors operating as a unit from one unloader valve.

often disintegrate and crumble when exposed to the weather. Many vertical joints occur. When such joints lie close to the edge of an excavation, or intersect it at an acute angle, the rock, when blasted, tends to break to the joints. This necessitates close line drilling and carefully controlled blasting to avoid overbreaks and an irregular rock working face. Most of the superficial rock layers are thin-bedded and have been exposed to the weather, which makes it difficult to get neat rock cuts in layers close to the surface.

Blasting at Downsville

About 50% of the 560,000 cu. yds. of rock to be removed in the weir and waste channel sections is friable and brittle sandstone. This is drilled and blasted in 16-ft. benches, or lifts, requiring only two changes of steel. The holes, spaced on 6-ft. centers, are drilled with eight UMW-40 Worthington and one MW-6 Joy wagon drills, each with 8-ft. feeds, utilizing Timken drill steel and bits. Air for the drills is supplied by four Model 630D Joy compressors, operating as a unit from one unloader valve. This arrangement of the compressors eliminates the necessity for a receiver tank. Air is delivered to the drilling area through a 6-in. pipe line.

The drill holes are loaded with 1¼ by 8-in. cartridges of Gelamite* 2, using a loading ratio of .66 lb. of dynamite to 1 cu. yd. of rock. The charges are primed with Hercules* Short-Period Delay Electric Blasting Caps, Nos. 1 to 9 inclusive, and are stemmed to the collar with approximately 4 ft. of sand. The leg wires of the caps are connected in series, and blasts are fired with a conventional blasting machine. The result from an average blast is a pile of muck easily excavated by the 2½ and 3-cu. yd. power shovels.

The remaining 50% of rock to be removed is poor. This necessitates careful line drilling on both walls of the cuts on a 1 to 6 slope.

The shaft, 18 by 32 ft., is to be sunk to a depth of 150 ft., with a 69 by 42.5-ft. valve chamber at the bottom. Two adjacent stilling chambers, 13 by 70 ft., are to connect with the valve chamber. The steel throughout the chambers will be wall plates and bents. A 325-ft. drift, 8 ft. in diameter, will be driven

*Reg. U. S. Pat. Off.

into the existing diversion tunnel, upstream and downstream.

All of the blasted rock is incorporated in the dam structure as refill and rock embanking. The 40,000 cu. yds. of dry paving to be placed on the upstream face of the dam is being taken from the present rock excavation and stock-piled for future use.

The activities of Rock Construction Corporation at Downsville are under the personal direction of Mr. Dunham, with the author supervising the engineering phases of the work. Edwin Young is foreman of the drilling and blasting crews.

Route No. 2 in Massachusetts

The use of Short-Period Delay Electric Blasting Caps on Mr. Dunham's various operations has contributed very materially in controlling rock breakage and backbreak, and the relative elimination of high-bottom rock between blasts. This was demonstrated on a project recently completed by Cabot Construction Company. The job, a subcontract, called for drilling and blasting 165,000 cu. yds. of hard, tough granite and sandstone formations on the relocation of highway Route No. 2, between Harvard and Littleton, Massachusetts. All of the rock blasted was used in fills along the new right-of-way and overpass approaches. It was necessary to break the rock in small pieces, as state specifications required that the placing of the materials had to be done in layers not to exceed 2 ft. in depth.

The rock cuts varied in depth from a few feet up to 45 ft. Holes for blasting, drilled on 6-ft. centers, were loaded with 1½ by 8-in. cartridges of Gelamite 2 and 1¼ by 8-in. cartridges of Hercules* 40% Gelatin Extra, on a ratio of approximately .75 lb. of dynamite to 1 cu. yd. of rock. The charges were primed with Hercules Electric Blasting Caps and Short-Period Delay Electric Blasting Caps. The loaded holes were stemmed with rock drill cuttings. Blasts were fired with a conventional blasting machine. The results were consistently satisfactory for easy digging by power shovels.

The economies realized from the use of Short-Period Delay Caps were conclusively demonstrated on this job.

(Continued on page 28)

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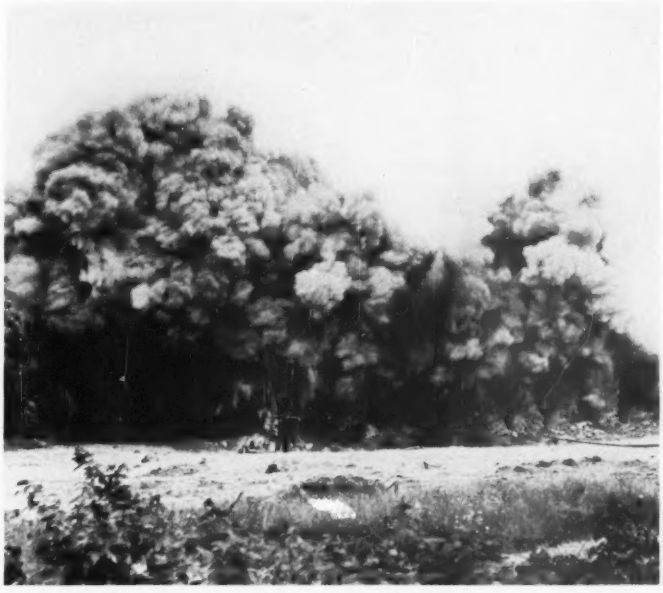
LEFT TO RIGHT: Rock Construction's operations are directed and supervised by Walter Dunham, Bruce Lattanzi, and Edwin Young.



ON ROUTE NO. 2: Heavy primary blasts were necessary on the Route No. 2 highway job to provide small stone to meet state specifications.

AFTER THE BLAST: The pile of small-sized rock above is typical of the results obtained from primary blasts on the Route No. 2 job.

TALES OF A GOLD MINER IN NICARAGUA

By C. CARLETON SEMPLE*

Some rambling recollections of mining operations under peacetime and wartime adversities

PART III

THE mine at Matagalpa had started out with no welder at all. I had ordered a 400-amp.-capacity Lincoln, just in time to get it shipped before priority regulations went into effect. A smaller welder is not practical at a mine because there is usually more cutting to be done than welding. No matter how small the mine, it will be served best by a welder of the maximum amperage that the manufacturer turns out. Luckily, our first order was large enough to last for the duration, and included plenty of all kinds and sizes of electrodes, with shielded arc. But we failed to anticipate how much carbons would be used. As substitutes, we tried about every form of carbon obtainable in the country. Finally, abandoned dry batteries were almost impossible to buy in Managua, at any price. As I remember, we bought a miniature welder which cost us about $9, and used little rods a-sixteenth or an-eighth of an inch in diameter. That little unit never seemed to have been idle; it was about as handy as a pocket in a shirt. I had ordered a plentiful supply of Railway Thermite but was informed that that sort of welding had become obsolete, and the address of the manufacturing company could not be found. Finally, I compromised by asking for aluminum powder suitable for the purpose, and I would try to make my own mixture. Like many other articles, it probably arrived long after I had left the mine, if it ever arrived at all. None of our mechanics had done any welding before, so it was thought better not to try atomic hydrogen until some native skill had been developed.

*Director, Empresa Zopel, Apartado 552, San José, Costa Rica.

As the ore from the mine was dumped upon the sloping grizzly of rails set rather close together, such rock as was possible was sorted out. Very likely some worthwhile ore that was too large to enter the crusher, and too hard to be broken readily by sledge, went out with the rock. There was no way of sampling such pieces without breaking them. Once that was done, they might just as well have gone through the mill. We figured that there would be dump scavenging anyway, before the inevitable shutdown.

Gauging Tonnage

The crushed ore was drawn from the crusher bin into a regular mine car and trammed a short distance, where it was dumped into the fine-ore bin. This car had been carefully calibrated for its carrying capacity of dry ore, and a mere car tally was all that we had for gauging tonnage. Boys were employed for keeping car tally and temptingly rewarded for reporting slack in car filling, or plugging up the tally board. For all such work, tramming was paid for on a per-car basis. In some mills in Nicaragua, where the tally system without weighing was depended upon entirely to gauge tonnage, it was the practice to take moisture samples and deduct the corresponding weight. The fact is that a car will fill with mixed sizes of ore with pretty near the same weight of dry ore for all moisture contents up to the point where the fines

are made mobile enough to run and fill in the spaces between the coarse ore. A car calibrated on 5% moisture is carrying approximately 15% moisture ore some days, and that weight is deducted from the tally. One is simply putting so many more pounds of dry ore equivalent into the bin without "debiting" the fill with full weight. It's a scheme by which one can show 95% or better mill recovery, if he can get away with it.

To permit crowding as much as possible, a screen discharge cone was used, with a reverse spiral of steel bar of one-inch-square cross-section fastened inside, like a corkscrew. Any large pieces of ore that arrived at the discharge were screwed back into the mill. Cyanide solution was fed by two flat spray pipes impinging upon the discharge screen, so that a sort of surge-and-washing action was going on just inside the mill. The charge tended to force its way out against the returning action of the spiral and two streams of solution. The solution came in from a small tank mounted on a platform above, in an out-of-the-way position over the discharge end. A sort of pinpoint charging with compressed air was effected in this tank, with the object of aerating the solution to the maximum.

There were only two serious accidents to the machinery in the entire six years, and both happened at the same time. After 27 months of operation, and without giving any signs of its existence, the key of the counter-shaft pinion began to be noisy and to work loose. The master mechanic, who was said to have graduated from the Pullman shops, assured me that everything was all right. He had the key banged back in with a sledge. In the night, the clatter got too much for me to stand, and I ordered the mill shut down. An examination in the morning showed both pinion and shaft utterly ruined, insofar as I could see. That was the last time I accepted reassurance from anyone against my own judgment.

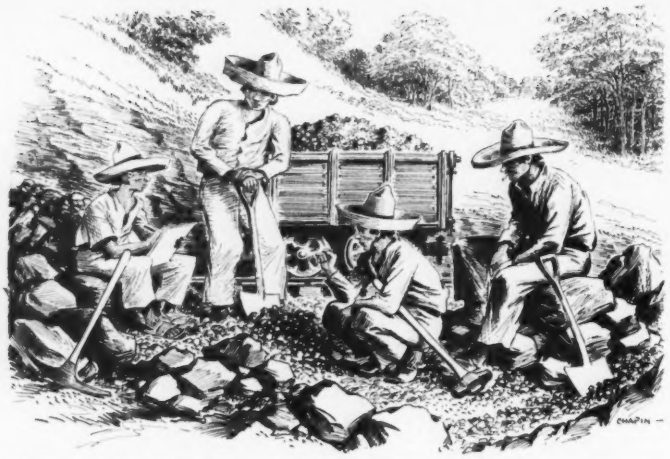
Thermite welding could have done a perfect job here, and I knew how to do it. There was one place where they might have Thermite—at the Canal Zone shops. So, I took a plane for Panama with the thought that any manufacturer thoughtful enough to supply a mill with an entire extra mill as a spare, certainly would supply a pinion or two, and shafts as well, for the other two mills. To get consent, a cable had to be sent to England. The answer came back to let me have what I wanted, provided I bought the whole mill. As the price asked was less than a set of linings, and I expected to be buying a mill for San Gregorio soon anyway, there were no objections on my part, and away we went to Remance. Sure enough, at the very first glance through the door, I spotted the crate with a shaft, and another with a pinion, all ready for shipment. They had never been unboxed. My, but that was a beautiful mill! While I was told it had been operated only eight months, it didn't look as if it could possibly have been in operation more than eight weeks—I would have been willing to settle on eight days. The lacquer wasn't even worn off the chain drives. Remance mine had less reserves than the mine I was working; in fact, it had one of those "little veins that isn't there."

Upon my return to Nicaragua, I found the compressor motor had burned out. Someone had put solid copper wire where the fuses belonged. The compressor and ball mill were driven by identical motors. A spare had been bought, so it all summed up to a rewinding job, with a hope that our last set of V-belts for the compressor would last for the duration. For, in celebration of our finding the spare shaft and pinions at Remance, the Japs had attacked Pearl Harbor that very night. Then I did pull a boner! Having ordered in Panama four sets of tires for both trucks, to be ready upon my return from Remance to take back with me to Nicaragua, I got a wrong hunch and cut the order in half.

NO NOISE, NO SLEEP: We were crowding the capacity of the treatment devices that followed grinding. If the mill stopped at night, I would wake up.

Milling Operations Revamped

We made a great many changes in our milling flow sheet, changes forced on us by war or prewar conditions. However, we did pretty well. As against 65 tons before my arrival, I increased the average to 101 tons each 24 hours of actual grinding time, and an average of 96 tons over both periods.



INEXPERIENCED WORKERS: The writer and a surveyor comprised the staff; the rest of the crew were inexperienced local men and boys.

Our best tonnage for any one day was 130, and we were crowding the capacity of all the treatment devices that followed the grinding. I always would wake up if the mill stopped during the night, and one visitor asked, "How do you know if the darned thing is running if you don't look at it?"

One interesting change, by the way, was the switch from a misfit classifier-settler to a 54-in.-wide duplex Dorr Classifier. This Dorr unit was an old machine bought in Colorado—it must have been one of the pair that Noah had with him in the Ark. The name plate had long since gone and, when it came to ordering spare parts, The Dorr Company could not recall the design. Some of the drive gear of later design would have to be ground away in places to fit in the bearings of the machine we had. Except for the quite considerable task of training the men on how to prevent a surge that might develop in the tank, our troubles from classifier capacity were over, and we could handle up to 130 tons a day. The abrasive quality of the pulp made itself manifest on the sides and bottom of the tank, and on the rakes and carrier frames. We repaired the rakes with ordinary angle iron, but I figured on trying out some resistant material such as manganese steel, even though it would have to be castings. A new tank was built, using ¼ and ⅜-in. plate and outsize, so that thin, white cast iron wear plates could be put into the bottom. Perhaps it would be better to use a rubber lining for such a job, if that commodity ever again became procurable after the war. I also resolved that the next such tank I rebuilt would be designed along the lines of bolted steel tank construction, so it could be shipped knocked down in an airplane. All the classifiers I have installed have always been shipped assembled. It's quite a problem to carry them on a camion, and to straighten out the bumps they received while aboard ship.

One problem we always had was to get the mill crew to adjust a diaphragm pump little by little. It was open her up or close her down, unless one spent all of his time in the mill to watch them. By this time, the staff was down to a surveyor and the writer. The surveyor came for a visit and chose to remain with us rather than to go back to his job on the Pan-American Highway. The rest of the crew were men and boys who had never traveled farther than a hundred-mile radius from Matagalpa. Under such conditions, one has to be satisfied with what one can get and do, although one may not be content about it. The thickener and storage tanks were installed with the brims only a few inches above the mill floor. Our greatest troubles came from what fell into them. The storage tank didn't matter, but tin cans and wrenches in the thickener caused a whole lot of delay, which could have been avoided had the floor been 6 ft. or so lower. At Saramarca and San Luis, in Peru, George Tingle used to stretch chicken wire over the thickeners to prevent such happenings. But after a visit to La India Mill, where tray thickeners were used, I reasoned that if the lower compartment was roofed over so that no one could get into it, there was no reason why the top could not have a cover. This we did and thereby saved ourselves much trouble.

RIVERBED SAND: In Central America, sand is scarce. We had to use riverbed sand which is nothing more than small pieces of igneous rock.

Another of our problems was cyanide. Sometimes we had white cyanide, sometimes Aero Brand. We paid for the cyanide f.o.b. factory, so much a pound of contained cyanide. Two pounds of Aero cost the same as one pound of white. But freight was on a total-weight basis, making that factor for Aero double that of white, per pound of contained cyanide. When cyanide stopped coming from Germany in 1939, Aero Brand from Canada was all that could be obtained, plus a little Cassell from England. Later Canada began shipping "eggs" of white cyanide. The Aero Brand had been in flakes and the German stuff "slices of pie," to pack solid in a cylindrical container with a hole down the middle to hook it out.

Equipment and Heavy Rainfall

A question is often asked as to the advisability of putting equipment out of doors in warm climates, where there is heavy rainfall. The heaviest rains I have ever experienced amounted to 3 in. in 24 hours. This represents only a 4% increase in tonnage of circulating solution, in the case of counter-current decantation. Also, I have seen all this take place within one or two hours, and that means an increase of 100% during the time. Such intense and heavy rainfalls are extremely rare, but when they happen they can play havoc in many ways. Most of the trouble with outdoor installations is caused by the wind, not by heavy rains. This is especially true in the case of small thickeners. I have had no experience with the enormous ones shown in the ads. But with ones up to 40 ft. in diameter, discharge may be blown so as to take place only on one side, or to blow a wave right over the side of the tank. Building the overflow trough complete, instead of using the wall of the tank for the outer side, using a higher board for the inner side, and offsetting the trough a few inches from the side of the tank, will cause discharge to take place in the annular space between the high inside board of the trough, holding back the wave.

The changes in the flow sheet required the substitution of a larger compressor, one giving 200 c.f.m. instead of 80 c.f.m. It is not easy to find good sand for concrete aggregate anywhere in Central America. The custom is to use riverbed sand, which is nothing more than small pieces of igneous rock. All too often it is used without being washed thoroughly. The resulting concrete is friable and would not be permitted where the building laws are strict. In making foundations at the mine, we washed the sand carefully, screening out all the dirt and fines from the material that was going to be used for fine aggregate. After this, we soaked it in a 2 to 5% solution of waterglass. Then it was drained and allowed to stand for several hours, before mixing it with the cement and gravel. We also used waterglass as an ingredient wherever a joint was to be made with older concrete. The use of waterglass is not usual among the builders in these countries. Local supply houses neither carry it nor know what waterglass is.

We had a well-equipped assay laboratory and also complete facilities for wet analysis. Every effort was made to encourage the bringing in of samples of any mineral found anywhere in the country, with no charge for assay or analysis. Notices were circulated that we would treat amalgam, returning the mercury and the sponge melted down into a bar, and we would grubstake prospectors and small operators. The object was, of course, to locate anything of promise in the district, in fact, anywhere in the country. That has always been my policy, and every company with which I have been connected has always approved it, and backed me up. I always had a sneaking hope that someone someday would bring in samples leading to the disclosure of a deposit of tin, beryllium, tantalum, tungsten, uranium—in short, any metal for which a demand could be created once an adequate supply could be assured, rather than the hope of finding gold ores, or even silver ores, of fantastic values. It did result in the finding of some 3,000 tons of old tailings that were well worth re-treatment.

Narrow Vein Outcrops

The first years of my job in Nicaragua were, specifically, one of salvaging, maybe of scavenging. It was only after those phases had been accomplished that the idea of finding a possible extension on which to continue operations came up for consideration. The field and the outlook were not encouraging. All known outcrops were of narrow veins, a meter in width being a maximum. To mine such deposits profitably, a fair persistency of pay ore in a continuous vein of great length is required. It was a foregone conclusion that it could not be expected in depth. Two factors were a must: an assay grade of no low value, and at least one dimension of the ore body of no mean proportions. The mine we were working was the narrowest vein of any being worked in the country. The workings had reached the greatest depth, all the ore had to be hoisted, then trammed for a long

(Continued on page 27)

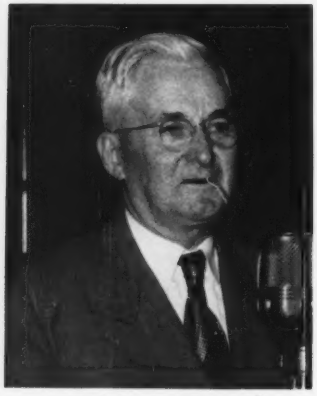
LOCAL PROSPECTOR: Notices were posted that we would treat amalgam and would grubstake prospectors. As a result, 3,000 tons of old tailings were located.

VICTORY CELEBRATION: The Union Pacific Coal Company officials entertained employes and guests at a dinner-ceremony in Old Timers' Building, Rock Springs, Wyoming, to celebrate the award of the Sentinels of Safety trophy and flag to the Reliance No. 7 miners.

RELIANCE No. 7 MINE AGAIN WINS SAFETY HONORS

Government officials and industrial leaders meet with employes of The Union Pacific Coal Company to participate in the award of the Sentinels of Safety trophy

For the second consecutive year, Reliance No. 7 mine of The Union Pacific Coal Company was awarded the Sentinels of Safety trophy for having had the best safety record among 159 bituminous-coal mines enrolled in the 1949 National Safety Competition. Officials of the company were hosts to approximately 575 employes, their wives, and friends at a gala dinner-ceremony in Old Timers' Building, Rock Springs, Wyoming, September 22, 1950, to honor the victorious miners.



I. N. BAYLESS: "During the past two years and to date this year our Reliance No. 7 miners have worked approximately 900,000 man-hours without a lost-time accident," said Mr. Bayless, president of the coal company. "We hope they make it three wins in a row."

After the invocation by the Reverend Thomas Rodda, everyone enjoyed a delicious dinner, served by the Ladies of St. Monica Sodality, and an unusual program of varied musical selections. The ceremonies began with an address by the toastmaster, H. C. Livingston, vice president of operations, in which he extended his personal congratulations, and those of his associates, to the men of Reliance No. 7 mine for their winning records in a nation-wide safety contest two years in a row. At the conclusion of his remarks, Mr. Livingston introduced the guests at the speakers' table, including Wyoming's two United States Senators, Joseph C. O'Mahoney and Lester C. Hunt. Each senator responded with brief messages of congratulations to the men of Reliance No. 7 mine for their splendid accomplishments, and expressed sincere hope for continued success in the promotion of safety in the company's mines.

I. N. Bayless, president of The Union

H. C. LIVINGSTON: The company's vice president of operations opened the program by extending congratulations to the Reliance miners on their having had the best records in safety in a nation-wide contest among the bituminous-coal mines two years in a row.

JOSEPH C. O'MAHONEY: After paying tribute to the Union Pacific miners for their accomplishments in safety on the job, the senior United States Senator from Wyoming said, "Today, as never before, we all should become sentinels of safety."

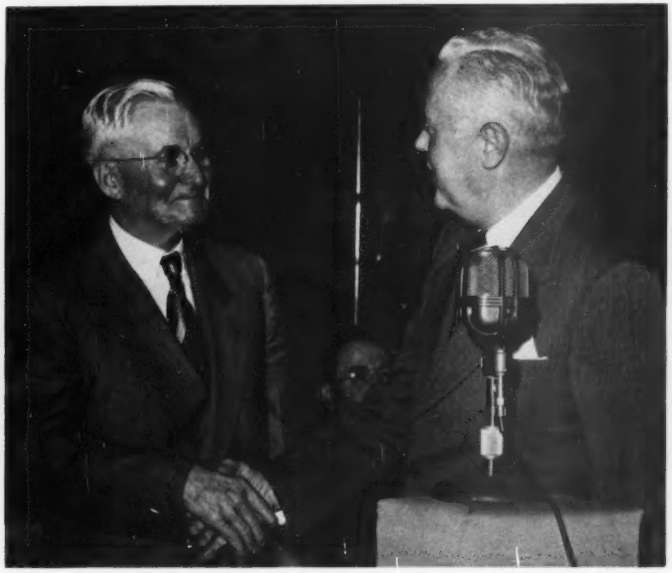
A. E. STODDARD: "The U.P. system's 48,000 railroaders and 56,000 stockholders join with me in being proud of your records in safe operations in underground coal mines," A. E. Stoddard, president of the Union Pacific Railroad Company, told the victorious miners.

Pacific Coal Company, then introduced A. E. Stoddard, president of the Union Pacific Railroad Company, as the guest speaker of the evening. In his opening remarks, Mr. Stoddard said: "What would the Union Pacific Railroad Company do without The Union Pacific Coal Company? We have to have coal to operate our railroad and we get it from your company, the largest producer of bituminous coal west of the Mississippi. Also, it is most gratifying to us to know that your company has some of the best miners and supervisors in the coal-mining business. On top of all this, you men have consistently made the best safety records in your group in these national contests.

"Personally, I want to thank each of you, and that includes the ladies—your wives and mothers—for the wonderful records you have established in safety on the job. And, in extending my thanks, I speak on behalf of the 48,000 railroaders in the Union Pacific system and for the 56,000 stockholders in our company. They are, as I am, proud of the records and the operating performances that you have accomplished.

(Continued on page 29)

LESTER C. HUNT: The junior United States Senator from Wyoming, a former governor of the state, expressed the hope that the Reliance miners would continue to make records in the National Safety Competition and retain possession of the trophy.



AWARDING THE TROPHY: On behalf of his associates, I. N. Bayless, left, president of The Union Pacific Coal Company, accepts the award of the Sentinels of Safety trophy and flag from J. I. Horty, managing editor of The Explosives Engineer.

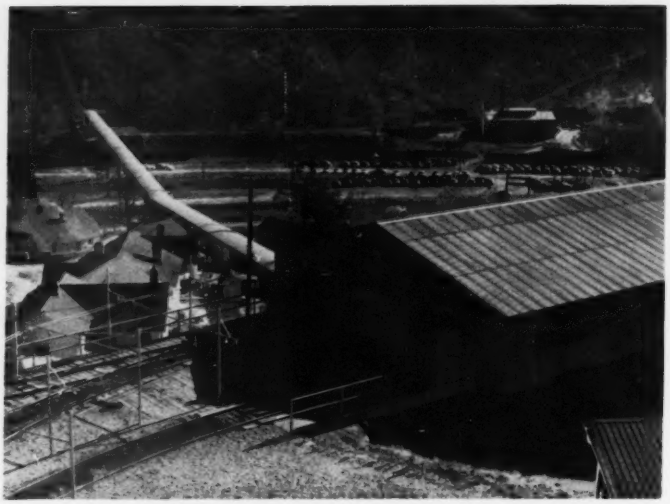
Mining Kentucky Coal

(Continued from page 9)

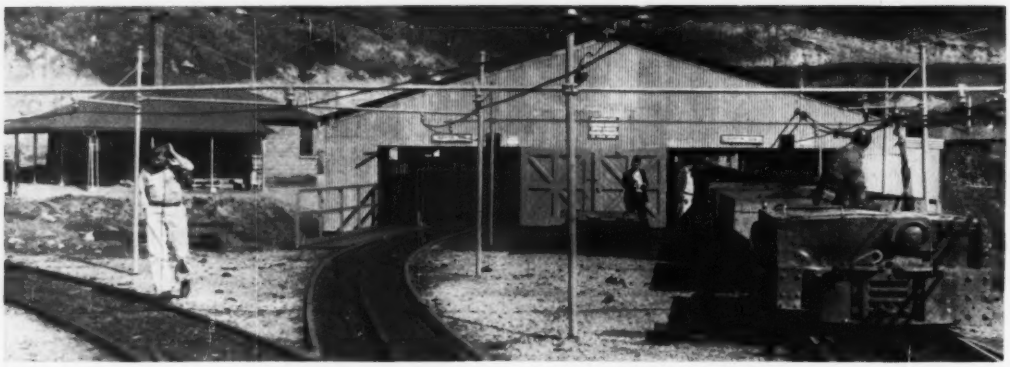
singly to complete the blasting operation. About 52 tons of coal are realized in each cut, which represents a ratio of about 6.1 tons of coal per pound of explosives. A substantial percentage of block and egg coal is generally obtained from the blasts.

An Effective Warning Signal

The coal is transported from the face to the butt entry by a shaker conveyor, where it is discharged onto a 30-in. rubber belt. The belt feeds out to the mouth of the butt entry and discharges the coal through a steel chute down a stope to the "B" seam from where it is loaded into 6-ton ACF drop-bottom cars. Loaded trips are pulled outside with 13-ton Jeffrey trams and dumped into two 765-ton storage bins. As the cars pass over the bins, they close automatically at the far end of the bins.



TO THE TIPPLE: The coal passes through the bottom of the storage bins by way of the Syntron vibrating feeders onto a 48-in. belt that conveys it through an enclosed gallery southward across the valley to the old tipple for final loading into railroad cars.



STORAGE BINS: Trips of 6-ton ACF drop-bottom cars loaded with coal are transported by 13-ton Jeffrey trams from the "B" seam in the mine to the outside, and their contents dumped into two 765-ton storage bins.

MANAGEMENT PERSONNEL: Left to right, E. K. Newman, general superintendent; J. H. Cope, assistant section foreman; P. W. Cole, section foreman; Alfred Trent, section foreman; F. C. Cole, foreman; H. E. Denney, electrical foreman; C. T. Palmer, maintenance foreman; A. J. McCarty, general mine foreman; and the author.

Soon after these bins were put in use, difficulty was occasionally experienced when one or more of the drop-bottom car doors failed to close. As a result, a warning device was put in the tipple. The warning signal was devised by A. J. McCarty, general mine foreman. It consists of a middle rail in the track and a stretch of 4/0 trolley wire on inverted hangers. When a door drops on the rail and the trolley wire, an electric circuit is made through dry cell batteries to a loud (Klaxon) horn and warns the motorman and the coupler that the door is down. If the door cannot be closed, the remainder of the trip can be pulled through the bin and backed up, to be pulled over the reclosing device. This comparatively simple warning system does an exceptionally effective job and has already effected savings many times its original cost.

The coal passes through the bottom of the storage bins by way of the Syntron vibrating feeders onto a 48-in. belt. The belt conveys the coal through an enclosed gallery southward across the valley to the old tipple, where it is loaded into railroad cars in grades of plus 5-in., 5-in. by 3-in., egg, and resultant. After being weighed, the loaded cars are transported to Chicago during the winter months and to Toledo during the warmer months, for lake transportation to Chicago.

The community of Benham, maintained by International Harvester Company, includes houses for the employes, grade and high schools that are operated under the Harlan County Board of Education, a modern hospital, a movie, a post office, and a modern store. The company also maintains a well-lighted stadium for playing football games at night.

TOWN BUILDINGS: Company buildings in Benham include, left to right, the store; the office headquarters; the post office; the office of the justice of the peace; the credit union offices; and the hospital. The company also maintains houses and schools for employes and their families.

SAFETY BULLETIN BOARD: At the end of each month the safety record of each miner is registered on this unique bulletin board, designed by G. W. Trent, company safety supervisor.

The management and operating personnel at Benham include E. K. Newman, general superintendent; C. L. Griggs, assistant general superintendent; C. H. Irwin, chief engineer; W. H. Boatright, master mechanic; A. J. McCarty, general mine foreman; J. W. Mowat, industrial relations manager; and T. G. Spuehler, auditor.

Tales of a Gold Miner in Nicaragua

(Continued from page 23)

distance, and the pumping of mine water had to be kept up throughout the year. The ore, what there was of it, had been of good grade. For the six years of operations, the total expenditures had been $8.30 a ton, including the return of the total original investment with 6% interest until the debt was liquidated en tota. There was no allowance for any value of plant or property, with gold at $35 an ounce. It was the custom to carry all assay plans, metallurgical accounts, and accounting of moneys, on the basis of gold at that price, with uniform exchange at five to one. Any variation was charged to cost of exchange. The difference between the actual money received from the refiner per ounce of gold and its standard price was assessed against the cost of refining. It shows up a little better in reports and statements to cut off the few cents an ounce that can be effected by crediting gold at a price under par, and at the actual amount received from the refiner. The costs of production totaled 82% of the expenditures.

After Pearl Harbor, when the question of permitting the mines to continue operations during the war came up for consideration, consent was finally given on condition that no development work of any sort on new veins would be done, and that such work must be limited strictly to the minimum required to keep the mills supplied. (To be continued.)

Blasting Rock Cuts

(Continued from page 19)

After a blast was fired, the drilling crews started drilling holes for the next blast without having to make allowances for backbreak or irregularly fractured rock from previous blasts. High-bottom rock in the working faces was practically eliminated.

Route No. 128 in Massachusetts

At this writing, Cabot Construction Company forces are engaged in drilling and blasting 80,000 cu. yds. of granite on the relocation of highway Route No. 128, between Lynnfield and Needham, Massachusetts. This new unit is a part of the huge Northern Circumferential Highway Project being constructed by individual contractors under the sponsorship of the Massachusetts Department of Public Works. The blasted rock is utilized in the fill areas.

ON ROUTE NO. 128: The 80-D Northwest shovel operator found easy digging in this bank of blasted granite on the Route No. 128 job.

The proximity of dwellings, buildings, and other types of structures along the right-of-way makes necessary the most careful blasting procedures. Rock in the deeper cuts is blasted in 16- and 20-ft. lifts.

Three UMW-40 Worthington wagon drills, powered by two 500-c.f.m. Worthington compressors, are used in drilling holes for blasting. The holes, spaced on 5 to 6-ft. centers, are loaded with 1¼ by 8-in. cartridges of 40% Gelatin Extra, on a ratio of .5 lb. of dynamite to 1 cu. yd. of rock. The 20-ft. holes are deckloaded. The charges are primed with Short-Period Delay Electric Blasting Caps and stemmed with sand. Blasts are fired by a 50-hole blasting machine. To date, the results have been uniformly excellent.

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Reliance No. 7 Mine

(Continued from page 25)

"We have 15 subsidiary companies in our organization, and the coal company is one of the outstanding units, if not the most outstanding, in the parent company. As I have said, you are the largest producer of coal west of the Mississippi River and, should the occasion arise, you could become larger than you are today. I am anxious to see a plant come to Rock Springs for the extraction of oil from coal. Also, I am very much interested in a turbine locomotive that will use coal as its fuel, instead of oil, gas, or other products. I am all out for taking everything out of coal except the ash, for all kinds of fuel and power uses on a national basis.

"Let me say to you again that all of us connected with Union Pacific, both in the railroad end of the business and in the coal company, are immensely proud of the safety records of Reliance No. 7 mine, the winners of the Sentinels of Safety trophy two years in succession. I sincerely hope you win it again this year."

Following Mr. Stoddard's address, the toastmaster, Mr. Livingston, introduced J. I. Horty, managing editor of THE EXPLOSIVES ENGINEER, to make the official award of the Sentinels of Safety trophy and flag to the men of Reliance No. 7 mine. After congratulating the winning miners on recording the best safety records in the last two National Safety Competitions, Mr. Horty said: "Union Pacific Coal Company's mines have been enrolled in the National Safety Competition for the past 17 years. During those 17 years, U. P. mines won the Sentinels of Safety trophy 11 times. Such outstanding achievements add up to the fact that carefully planned programs of safety have been, and are, in force, and that everyone from top to bottom has cooperated to make them work. But, most of all, it means that you men working in the mines have made these perfect safety records possible because of your own good judgment and common sense." The speaker then presented the trophy and flag to Mr. Bayless.

In accepting the awards, Mr. Bayless said: "The ceremonies this evening mark one of the high spots in our company's safety efforts. Reliance is well on its way to a third consecutive victory, not having had a single lost-time accident so far during 1950. Its record for the past two years and to date this year totals approximately 900,000 manhours without a lost-time injury." The speaker called on Leon Wisniewski, a machine runner in the winning mine organization, to come forward and receive the trophy and flag as the representative of his associates in the mine. "Thank you, Mr. Bayless, Mr. Horty, and THE EXPLOSIVES ENGINEER magazine," remarked Mr. Wisniewski. "It is with a great sense of pride that I, on behalf of my associates, accept the Sentinels of Safety trophy and flag. We find ourselves challenged to take up the work of promoting even better standards of safety. We will do everything we can to help in the development of more safety consciousness, not only in our own mine, but, by our example, in other coal mines throughout the country."

Individual Certificates of Achievement in Safety were presented by E. H. Denny, U. S. Bureau of Mines representative from Denver, Colorado, to William Spence, mine superintendent of the Reliance district. Later, Mr. Spence presented a certificate to each man in the Reliance No. 7 mine organization.

The ceremonies were concluded by the pronouncement of benediction by the Reverend Thomas Rodda.

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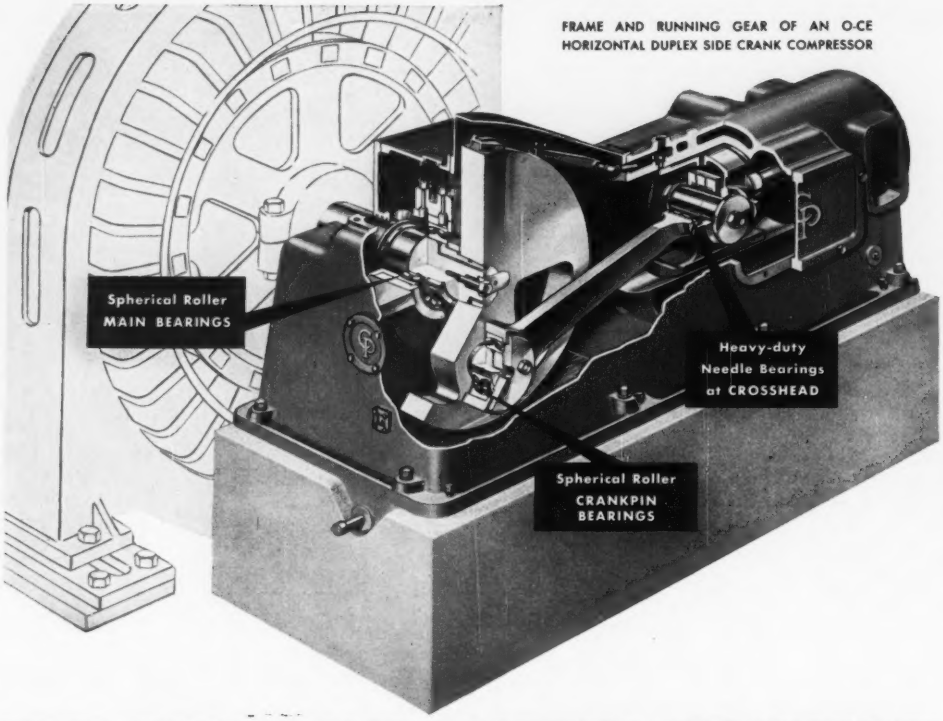


FRAME AND RUNNING GEAR OF AN O-CE
HORIZONTAL DUPLEX SIDE CRANK COMPRESSOR

FIRST WITH ROLLER BEARINGS THROUGHOUT

IN A HORIZONTAL DUPLEX COMPRESSOR

- SPHERICAL ROLLER MAIN BEARINGS
- SPHERICAL ROLLER CRANKPIN BEARINGS
- HEAVY-DUTY NEEDLE BEARINGS AT CROSSHEAD

Chicago Pneumatic's Class O-CE AIR COMPRESSORS are the first horizontal duplex, side crank compressors to have anti-friction roller bearings throughout . . . spherical roller main and crankpin bearings . . . heavy-duty needle bearings at the crosshead pins.

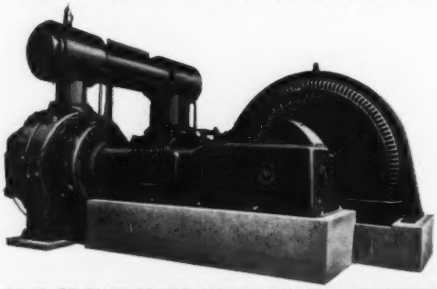
To the user, "roller bearings throughout" means easier and cheaper maintenance, and no possibility of improper bearing adjustment with resultant serious damage to frame and running gear.

Roller crankpin bearings permit the use of solid-end connecting rods—the strongest, safest type.

This revolutionary innovation is made possible by the recent development of the oil injection method of bearing and crank disc installation and removal. This simple method, requiring only a hand-operated oil pump and ordinary hand tools, is employed also for the application or removal of gears, couplings and sleeves on shaft ends.

Class O-CE Motor-driven Compressors are furnished in sizes up to 2000 h.p.

Write for Bulletin 726-5



CLASS O-CE TWO-STAGE MOTOR-DRIVEN COMPRESSOR

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Built in Light, Medium and Heavyweight sizes . . . the latter models drill to as much as 45' depths, using steel changes up to 15'—the Medium has "Hydra-Lift" hydraulic control.

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JOY *Lightweight* WAGON DRILLS

THE EXCLUSIVE "DRILL AND BLOW" FEATURE MEANS YOU BLOW THE HOLE AS YOU DRILL!

- ★ LIGHTWEIGHT only 750 lbs.
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"Hercomites," for example, come in fast, intermediate, and slow heaving-action types. One series is especially designed for poorly ventilated places. All offer improved water resistance and, like "Gelamites," come in handy Tamptite® cartridges. For full information, write for illustrated booklet, "Hercomites and Gelamites for Lower Blasting Costs."

HERCULES POWDER COMPANY
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DETONATE

For better BLASTING!

WITH PRIMACORD

The many advantages of Primacord make it the choice where safety, simplicity of hookup, and ease of handling are factors to be considered.

Primacord, because of its speed, detonates practically instantaneously, yet the infinitesimal lag between holes and rows of holes obtains greatest results from a minimum quantity of explosives.

Because it cannot be set off by friction, sparks or ordinary shock and is impervious to stray electrical currents, Primacord offers a safety factor to many blasting operations.

Primacord is wound on easy to handle lightweight spools, so that loading and hook-ups are done easily.

4 Types of Primacord

Primacord is made in four standard types, each designed to obtain greatest effectiveness under varying working conditions — each with the same high degree of dependability.

PLAIN PRIMACORD. For shallow holes and surface trunkline use, Plain Primacord is recommended. Although light in weight (a 1000-foot spool weighs only 19 lbs.) it has tensile strength of 113 lbs.

REINFORCED PRIMACORD. For deep holes where extra tensile strength or resistance to abrasion are desirable, depend on Reinforced Primacord. Tough, but resilient and easy to handle, Reinforced Primacord has the same detonating qualities as other Primacord-Bickford types. Weight 20 lbs. per 1000-ft. spool.

WIRE COUNTERED PRIMACORD. Armored with closely stranded brass wire, Wire Countered Primacord is the answer to problems involving deep, ragged holes and high abrasive conditions. The wire sheath also increases the tensile strength to 220 lbs. Weight per 1000-ft. spool, 35 lbs.

PLASTIC REINFORCED PRIMACORD. To meet the demand for a strong, waterproof detonating cord resistant to abrasion and to the acids commonly encountered, Ensign-Bickford developed Plastic Reinforced Primacord. With tensile strength of 250 lbs., users find it ideal for extremely deep holes, river crossings, or where water is a problem. Weighs 22 lbs. per 1000-ft. spool.

Blasters who use Primacord consistently agree there is no substitute. For complete information, consult your explosives supplier . . . or write to us direct.

THE ENSIGN-BICKFORD COMPANY
Simsbury, Connecticut
Also Ensign-Bickford Safety Fuse — Since 1836

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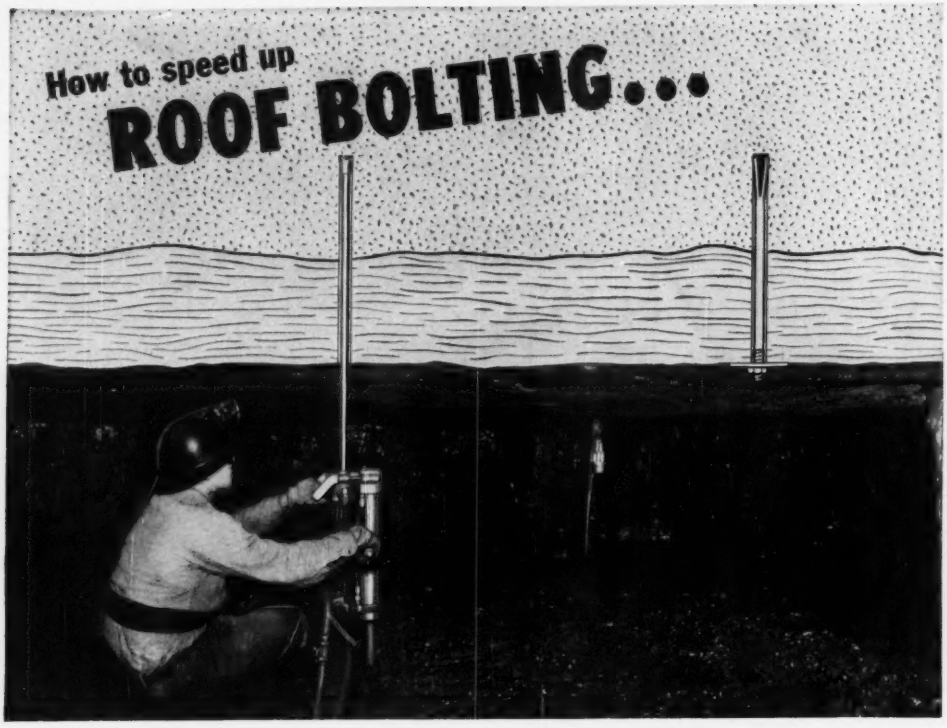
PRIMACORD-BICKFORD Detonating •Fuse•



... with the popular I-R "Big Three"

ROOF BOLTING COMBINATION

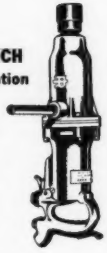
1 RP 38 "SHORT-LEG" STOPER
more power, less weight

Light in weight, well-balanced, this powerful, ultra-compact RP 38 "Short-Leg" Stoper can be readily handled in seams as low as three feet. It provides automatic rotation for fast, easy drilling of roof holes, and has plenty of power for driving roof bolts.

For extra heavy drilling, use Model RP-48.

2 SIZE 534 IMPACT WRENCH
maximum torque, easy operation

Tightening the nuts in roof bolting is done quickly, easily with the I-R 534 Impact Wrench. This air-operated tool exerts a more powerful turning effect than that of any other portable wrench of this size. Extra deep sockets are available.



3 CARSET JACKBITS
faster drilling, longer life

Widely-used, long-lasting Carset Jackbits, with inserts of tungsten carbide, practically eliminate bit changing and the time loss this means. They stay sharp longer. Increase drilling speed 50% or more.

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